PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04Q 7/24

A1

(11) International Publication Number: WO 97/29605

(43) International Publication Date: 14 August 1997 (14.08.97)

(21) International Application Number: PCT/SE97/00108

(22) International Filing Date: 23 January 1997 (23.01.97)

(30) Priority Data:
9600503-8 12 February 1996 (12.02.96) SE

(71) Applicant: TELIA AB [SE/SE]; Mårbackagatan 11, S-123 86 Farsta (SE).

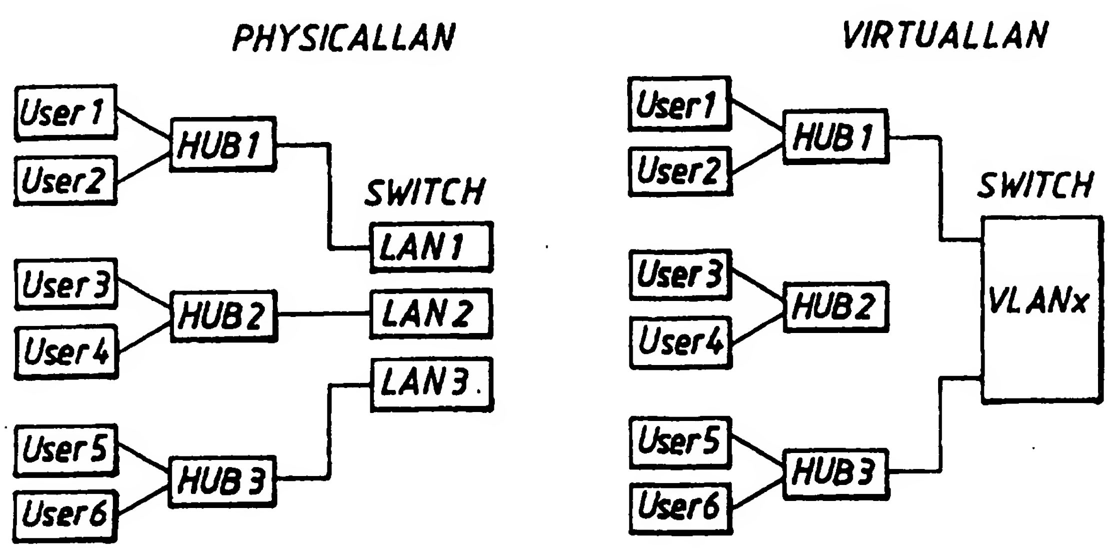
(72) Inventor: KAVAK, Nail; Myrstuguvägen 359, S-143 32 Vårby (SE).

(74) Agent: KARLSSON, Berne; Telia Research AB, Rudsjöterrassen 2, S-136 80 Haninge (SE).

(81) Designated States: NO, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: A WIRELESS ATM SWITCHED LOCAL AREA NETWORK SUPPORTING MOBILITY OF MOBILE TERMINALS



(57) Abstract

The present invention is a wireless high speed virtual LAN, particularly adapted for residential and small business use. Wireless access results in low cost and flexibility. Users are able, if necessary, to access a wired enterprise network and be connected to closed user groups at high speed. The VLAN concept enables increased flexibility in terms of system configuration, increased performance and increased security for both users and network operators. Users can logically change their group membership thereby gaining access to different network services without changing their physical location. Terminal mobility is enabled by provision of a seamless handoff scheme. System efficiency is enhanced by use of a path migration scheme which preserves data continuity and is transparent to users.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia
AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgystan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam

A WIRELESS ATM SWITCHED LOCAL AREA NETWORK SUPPORTING MOBILITY OF MOBILE TERMINALS

The present invention relates to a wireless ATM based virtual local area network (LAN) and, more particularly, such a LAN arranged to support seamless handoff between base stations and providing the ability to migrate transmission paths following handoff.

The rapid proliferation of portable commuters,, the availability of deregulated radio bandwidth and the prospect of reduced costs for office rearrangement has led to the emergence of wireless LANs as an interconnect technology. Wireless LANs enable the realisation of "computing anywhere at any time". Mobility and portability can be expected to create entire new classes of subscriber applications.

First generation wireless LANs are, in reality, mere extensions of traditional LANs, i.e. the extension of existing LANs by, e.g. radio, or infra-red, and are employed where wiring difficulties are encountered, for example factory floors, stock exchanges etc.. Wireless interconnections between LANs located in different buildings have also been provided.

End users may be given nomadic access to a wireless LAN via a central hub. Such access is particularly valuable to endusers who need to transfer large data files from a portable commuter to a backbone information network while returning to their offices. Wireless LANs may also be used to permit ad hoc networking between a group of portable users, e.g. in a class room, or meeting.

It can be expected that nomadic personal computing devices will, in the future, be universally used. Such

devices will inevitably need to be networked and will support a variety of network attachments. When they are remotely located from their normal location, such devices will be connected to wireless networks, when used within a home office environment they will be interconnected by infra-red communications links, and when docked they will use physical wire interconnections. Such devices will, in the not too distant future, replace the current generation of cellular phones, pagers and digital notebooks.

Intelligent wiring hubs and concentrators simplify some of the tasks associated with LAN reconfiguration. Most LANs confine such tasks to a centralized wiring box. Modular and programmable products use a variety of techniques to overlay logical LAN topologies on the underlying cable distribution system. Some systems even provide software enhancements to assist system administrators to document configuration and management data.

However, station relocation and LAN segment reassignment still demand physical access to the network hub for cable and port rearrangements. Relocated stations must be assigned new IP addresses and other stations must be advised of address changes. Such procedures can be cumbersome, time consuming and expensive to implement, especially when wiring hubs are located in different places. As progressive modifications and updates are made to a LAN, the probability of error grows and documentation becomes out of date. This can result in considerable downtime for a system. Virtual LANs seek to overcome many of these problems.

The present invention is a wireless high speed virtual LAN, particularly adapted for residential and

small business use. Wireless access results in low cost and flexibility. Users are able, if necessary, to access a wired enterprise network and be connected to closed user groups at high speed. The VLAN concept enables increased flexibility in terms of system configuration, increased performance and increased security for both users and network operators. Users can logically change their group membership thereby gaining access to different network services without changing their physical location. Terminal mobility is enabled by provision of a seamless handoff scheme. System efficiency is enhanced by use of a path migration scheme which preserves data continuity and is transparent to users.

According to a first aspect of the present invention, there is provided a wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network, characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, and in that both intra-switch and inter-switch mobility is supported by said infrastructure network.

Central control means may be provided for reconfiguring the wireless local area network by reassigning logical addresses.

Said wireless local area network may be structured into a plurality of logical domains within which traffic can be confined and which exist independently of a mobile terminal's physical location.

Said wireless local area network may include overlapping logical domains.

Preferably, terminal mobility is achieved by use of a seamless handoff scheme.

An individual data direct VCC may be established between each pair of communicating mobile terminals.

An MVD and an SRD may be provided.

A signalling VC may be employed for supporting command channel connections.

A handoff VC may be employed for transmission of messages relating to terminal mobility.

Preferably, said seamless handoff scheme employs the following messages:

- a location message;
- a connection message;
- a routing message; and
- a complete message.

When a moving MT initiates a location query in order to obtain an ATM address for a base station in a new cell, the location query may be transmitted to an original base station as a location message.

When an MT initiates a connection query in order to obtain MT associated data from the MVD, the connection query may be transmitted as a connection message.

A routing message may include data identifying MT-associated VCCs, an originating base station, and a new base station and may enable an ATM switch to identify

whether a handoff is inter-switch, or intra-switch.

Preferably, a complete message, containing data on all MT-associated VCCs, is transmitted by an ATM switch, whenever the ATM switch has completed an SRD modification, to a new base station.

Preferably, each MT within an area served by an ATM switch has a unique VCI value.

First means may be provided for determining, after completion of an inter-switch handoff, whether, or not, communication is established over an optimum path, and second means may be provided to migrate said communication to an optimal path, if said path is sub-optimal.

A partner message may be employed to transmit an ATM address of a partner BS to an originating BS.

During path migration the flush message protocol of the LAN emulation protocol may be employed to maintain frame order.

According to a second aspect of the present invention, there is provided a wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, in that both intra-switch and inter-switch mobility is supported by said infrastructure network, in that central control means are provided for reconfiguring the wireless local area network by reassigning logical addresses, and in that there is provided an MVD and an SRD, in which an individual data direct VCC is established between each

pair of communicating mobile terminals.

According to a third aspect of the present invention, there is provided, in a wireless local area network, as set out above, a method of providing seamless intra-switch handoff, for an ATM switching node, of a MT from a first BS to a second BS, characterised by the following steps:

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;
- the first BS transmits a routing message to the ATM switching node;
- said ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said ATM switching node;
- said ATM switching node sends a complete message identifying all new VPI/VCI pairs to said second base station;
- said second base station adds new MT-pair-VCC associated entries to its MVD; and
- the second base station re-starts data transmission.

According to a fourth aspect of the present invention, there is provided, in a wireless local area network, as set out above, a method of providing seamless inter-switch handoff, of a MT from a first BS, connected to a first ATM switching node, to a second BS, connected to a second ATM switching node, characterised by the following steps:

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;

- the first BS transmits a routing message to the first ATM switching node;

- the first ATM switching node establishes an SVC to the second base station for each of the MT-associated VCCs;

- said first ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said first ATM switching node;

- said first ATM switching node transmits a coupling message to the second base station;

- the second base station adds the new MT-pair VCC entry into its MVD; and

- the second base station re-starts data transmission.

If said second ATM switching node detects that an output port and an input port of a mobile connection are identical, so that a longer looped loop path exists, the following steps may be performed:

- said second ATM switching node releases the SVC established for the longer loop path;

- said second ATM switching node sends a routing message to a third adjacent ATM switching node;

- the third ATM switching node establishes a new

SVC to the second base station;

- the third ATM switching node searches for a loop path and, if no loop path is detected completes the handoff procedure;

- if said third ATM switch detects a loop path, the above procedure is repeated with a fourth adjacent ATM switching node.

On completion of a handoff procedure for a first MT, in active communication with a second MT, between a first base station and a second base station, said second base station may establish a new VCC to a remote base station, via which the second MT is connected, by executing a routing scheme, and if said VCC differs from the VCC established at handoff, communication may be migrated to the new VCC.

Said routing scheme may be a shortest path scheme.

Frame order may be preserved by using the flush message protocol of the LAN emulation protocol.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic comparison of a physical traditional LAN with a virtual LAN.

Figure 2 illustrates, in schematic form, a wireless virtual LAN based on an ATM network infrastructure.

Figure 3 is a schematic illustration of intra-switch and inter-switch mobility in a virtual wireless LAN having an ATM network infrastructure.

Figure 4 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, just before handoff.

Figure 5 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, immediately following an intra-switch handoff.

Figure 6 is a schematic illustration of a virtual wireless LAN, having an ATM network infrastructure, immediately following an inter-switch handoff.

To facilitate an understanding of the present invention a glossary of the abbreviations used in the specification is set out below:

ATM: Asynchronous Transfer Mode

BS: Base Station

BSA: Basic Service Area

BSS: Basic Service Set

IP: Internet Protocol

LAN: Local Area Network

LE: LAN Emulation

MAC: Medium Access Control

MT: Mobile Terminal

MVD: MT pair-VCC mapping Database

NNI: Network Node Interface

SRD: ATM Switch Routing Database

SVC: Switched Virtual Connection

UNI: User Node Interface

VC: Virtual Channel

VCC: Virtual Channel Connection

VCI: Virtual Channel Indicator

VLAN: Virtual Local Area Network

VPI: Virtual Path Indicator

WAN: Wide Area Network

A VLAN has the following characteristics:

- mobility;
- use of logical domains;
- bandwidth control and conservation;
- connectivity;
- security; and
- conservation of investment;

these characteristics are briefly reviewed below.

For a VLAN, as compared to a traditional LAN, the processes associated with system reconfiguration and end changes can be made substantially more dynamic.

Traditional LANs must be reconfigured at the switching hub whereas VLANs can be reconfigured, by means of software driven processes, from a central controller, or server. Traditional LANs require that relocated stations be assigned new IP addresses. In a VLAN, only the logical address of relocated stations change, IP addresses remain the same. The VLAN hub performs the translation between IP address and logical address.

The simplest LANs support a single workgroup with a single shared medium communication path. As the number of users and the traffic increases, bridges can be employed to segment a LAN. However, users still share the same amount of bandwidth. Switching hubs use high-bandwidth backplanes to support multiple, separate, LAN segments and to offer dedicated bandwidth to high powered workstations. VLANs permit multiple workgroups, or logical domains, to be defined. Traffic can be restricted to the stations, servers and other resources allocated to a given logical domain. Overlapping, or cross domains, can be created to enable certain members of one domain to access members of another domain. Logical domains exist independently of their members' physical connections and may include members on more than one LAN segment. Because logical domains are easy to reconfigure, users can be regrouped faster and more frequently than is possible in the traditional LAN environment.

VLANs can restrict broadcasts to the logical domain in which they originate. Adding users to one domain does not affect the availability of bandwidth to users in other domains. As requirements change, workstations can be reassigned to other appropriate domains, or the domains themselves can be reconfigured. For example, several users working on a high bandwidth-intensive application might be grouped into a single logical

domain.

Most switched hubs restrict connectivity to users sharing the same LAN segment. Bridges, or routers, are needed to connect different segments. In a VLAN environment, bridges and routers can be replaced by overlapping domains and support selective interconnectivity.

VLAN logical domains can be used to confine broadcast traffic to a desired working group and to restrict user access to certain resources.

The price of VLAN capability is concentrated in the cost of the switching hub. However, upgrades to VLAN equipped hubs do not require any changes in wiring, network adapters, management tools, workstations, or workstation software. VLANs allow stations to keep their existing IP addresses as they are reconfigured.

The primary benefit of using a VLAN switching hub is that there is no need for a technician to go to a wiring box and manually change hub port connections. Network managers, or administrators, can reconfigure a network from a central location. The reassignment of a workstation, from one LAN segment to another, is merely a matter of pointing and clicking a mouse on a network diagram on a VDU screen.

Figure 1 illustrates the difference between a traditional physical LAN and a VLAN. The users on HUB3, of the LAN shown on the left of Figure 1, all share the available bandwidth of the LAN segment. Every physical port is in the HUB and the switch is configured to belong to a particular LAN segment. In the VLAN, illustrated on the right of Figure 1, the HUB, or switch, can handle any number, or combination, of VLAN

segments. The configuration is not physical, but rather logical. The switches are able to logically separate different broadcast domains. VLAN architecture offers three key advantages over basic switched LANs:

- logical, rather than physical, updating;
- inter-domain security; and
- reduced broadcast areas.

Turning now to Figure 2, there is illustrated a wireless VLAN according to the present invention. The basic building block of the wireless network is a radio cell called a basic service area. Each BSA, C_0 ..... C_7 is covered by a base station, labelled BS0 .... BS7, in Figure 2. The BSs exchange radio signals with mobile stations, not shown in Figure 2. A set of MTs, within a BSA, that are able to mutually communicate, is referred to as a Basic Service Set, or BSS. A wireless VLAN which comprises a single BSS has a limited range and can operate only within a local environment. To overcome the problem of range, several BSSs must be interconnected. This interconnection may be achieved via a wireline infrastructure network, a WAN, or the Internet. In such a system, BSs provide a wireless communications link between the backbone infrastructure network and mobile terminals. The backbone infrastructure network of the present invention is a switched ATM network comprising ATM switching nodes A ..... F, see Figure 2. The ATM network can operate on the basis of the LAN emulation (LE) defined in the ATM Forum. The LE enables, inter alia, connectivity between LAN bridges. One property of such a network is that all ATM cells, for frames transmitted between two LANs, are assigned the same VPI/VCI. The cells of the frame are reassembled at the destination bridge which forwards

those cells to the final destination station, in accordance with the MAC address. This means that ATM switches along the VCC cannot distinguish cells from different frames. Since terminal mobility is one of the key objectives of the present invention, the realisation of handoff between BSs must be given careful consideration.

Mobility, i.e. movement of a MT during the process of data communication, can be classified into one of two categories, intra-switch mobility and inter-switch mobility. These two categories of mobility are described, below, with reference to Figure 3. Intra-switch mobility occurs where handoff is between two BSs connected to the same ATM switching node, whereas inter-switch mobility occurs where handoff is between two BSs connected to different ATM switching nodes.

Consider the following example. An ATM switch is connected to several BSs, each of which covers a single BSA. Assume that a mobile terminal MT_j is in the process of moving from BSA C_i to BSA C_j, having base stations BS_i and BS_j, respectively, both of which are connected to the same ATM switching node. In this case the mobility is intra-switch mobility. On the other hand, if BS_i and BS_j had been connected to different ATM switching nodes, the handoff, (mobility), between BS_i and BS_j would have been inter-switch. The mechanism by which all frames transmitted between a pair of LANs shares a VCC, as defined by the ATM Forum, is not well suited for use in a wireless LAN because of terminal mobility.

Consider the simple mobility case illustrated in Figure 3, where two mobile terminals MT_j and MT_i located in BSAs C_0 and C_5 are in the process of mutual communication. If MT_j moves from BSA C_0 to C_1, an intra-switch handoff is required. To achieve this, ATM cells

routed to MT_j from MT_i must be forwarded from BS0 to BS1 by ATM switch C. However, ATM switches lack the capability to distinguish which cells on the VCC should be forwarded to BS1 rather than BS0. Thus, the only way to provide a seamless handoff is to establish a new VCC, designated VCC(0,1) between BS0 and BS1. In other words, BS0 must reassemble ATM cells destined for MT_j, check the destination address, which will have changed following the handoff, segment the ATM cells into ATM frames and forward the cells via the newly established VCC(0,1) to BS1. This approach is simple and straight forward and enables the original scheme for interconnection of wireline LANs to be applied directly. However, the communication path between MT_j and MT_i has been elongated, e.g. VCC(5,0) must be extended by the addition of VCC(0,1). This problem of path elongation is more serious in the case of inter-switch handoff. Consider the case in which MT_j moves from BSA C0 to BSA C3. In this case the communication path from MT_i to MT_j would be elongated from VCC(5,0) to VCC(5,0) + VCC(0,1) + VCC(1,2) + VCC(2,3), as shown in Figure 3. It is clearly desirable to have some mechanism which will permit an elongated communication path, to be migrated to a shorter communication path should such a shorter path be available. For example, as can be seen from Figure 3, it would be beneficial if path VCC(5,0) + VCC(0,1) + VCC(1,2) + VCC(2,3) could be migrated to a shorter path such as (BS5, F, A, D, BS3), or (BS5, F, D, BS3).

An intra-switch handoff can be readily achieved by informing the ATM switch node involved, (only one switch node is involved in an intra-switch handoff), to change the data path from one port to another, internally. Where an inter-switch handoff is required, it may be necessary to establish a shorter VCC, if possible. Thus, path migration is recommended as a means of

changing an inefficient communications path to a more efficient communications path.

A seamless handoff scheme must satisfy the following requirements:

- data continuity;
- transparent to other mobile terminals; and
- minimum routing load (elongated communication path) in the infrastructure network.

If seamless handoff is to be efficiently achieved, a pair of MTs in active communication must establish an individual data direct VCC. Given that an individual data direct VCC is established, it is relatively easy to achieve the requirements listed above.

Each pair of communicating MTs has an individual virtual connection which is identified by a virtual channel identifier (VPI/VCI). Thus, each BS must maintain an MT pair-VCC mapping database, usually referred to as an MVD. At each ATM switching node, the incoming VCC (in-VCC) and incoming port (in-port), for a received ATM cell, are used as indices in the SRD to enable the outgoing port (out-port) and outgoing VCC (out-VCC), associated with the next link, to be uniquely identified. Thus, at each switching node, the mapping table (in-VCC, in-port, out-VCC, out-port) uniquely defines a VCC.

A predefined VPI/VCI value, VPI = 0 and VCI = 5 are used to support command channel connections, i.e. the signalling VC. These connections are established in real time using appropriate signalling procedures.

A handoff VC is defined by appropriate VPI/VCI values and is used to carry messages relating to MT mobility and handoff. The handoff VC is a point-to-point connection between a BS and an ATM switching node, or between two ATM switching nodes.

For the sake of simplicity, the term "mobile connection" is used to refer to the virtual connection between any pair of MTs. These mobile connections are dynamically established by signalling protocols.

Consider now, by way of example, the connection topology illustrated in Figure 4. Figure 4 shows three ATM switching nodes X, Y, Z and six BSAs, C_0 to C_5. Base stations (BS_0, BS_1), (BS_2, BS_3) and (BS_4, BS_5) are connected to ATM switches X, Y and Z respectively. Initially there are three mobile connections, namely (a,c), (b,c) and (a,d). Each mobile connection is identified by a sequence of VPI/VCI values, for (a,c), (b,c) and (a,d), these are:

(a,c) - (10/700,30/400,60/100);

(b,c) - (10/800,30/500,60/200); and

(a,d) - (10/900,30/600,60/300).

The VPI values are based on the assignment of virtual paths between two ATM switching nodes, or between an ATM switching node and a BS. Two, or more, MT handoff processes cannot be handled at the same time within an ATM switching node. It is, therefore, necessary to provide a mechanism for resolving handoff conflicts between MTs located within an area served by a single ATM switching node and having a unique VCI value. In the present example, the VCI is randomly selected and used only to identify an end-to-end mobile

connection. The contents of the MVDs in BS_0 and BS_1, together with the contents of the SRDs in ATM switching nodes X and Z, are also shown in Figure 4.

In order to perform a seamless intra-switch handoff, it is necessary to define some handoff messages to be used in the handoff process. There are four types of handoff message:

- location message: The moving MT initiates a location query to get the ATM address of the base station of a new BSA (ATM BS_{new}) and transmits it to the base station in the original BSA ($BS_{original}$) in a location message.

- connection message: The moving MT initiates a connection query to obtain its own MT-associated information from $BS_{original}$, i.e. the contents of the MVD, and sends it to BS_{new} in a connection message.

- routing message: $BS_{original}$ sends a routing message containing (MT-associated VCCs; ATM $BS_{original}$; ATM BS_{new}) to the attached ATM switch via a handoff VC. On the basis of the user/network node (UNI/NNI) signalling information, the ATM switch can identify whether a handoff is an inter-switch handoff, or an intra-switch handoff. Depending on the MT-associated VCCs, the ATM switch can alter the corresponding duples in the SRD to modify the communications path.

- Complete message: Whenever the ATM switch has completed SRD modifications, it sends a complete message with all MT-associated VCCs to BS_{new}.

An example of the procedure used to handle intra-switch handoff will now be described with reference to Figure 5, which shows the connection topology illustrated in Figure 4 after a mobile MT_c has moved from BSA C_0 to C_1. It is assumed that MT_c has initiated location and connection queries. It should be noted that MT_c has two mobile connections, namely with MT_a and MT_b. The steps used to implement an intra-switch handoff are as follows:

1. MT_c issues a location message containing the ATM address of BS_1 and BS_0, and a connection message with MT(a,c) - 60/100 and MT(b,c) - 60/200 to BS_1.

2. BS_0 then sends a routing message (60/100, 60/200, ATM BS_1) to ATM switching node X.

3. ATM switching node X modifies the corresponding duples of the MT-associated VCCs in the SRD and issues a complete message with all new VPI/VCI pairs, i.e. VCCs 70/100 and 70/200 to BS_1.

4. BS_1 adds the new MT-pair-VCC entries to its MVD and restarts the data transmission procedure.

Figure 5 shows the mobile connections and the contents of the corresponding MVDs and SRDs after the intra-switch handoff. The data paths are changed, from one ATM switch port to another, internally. The routing load on the ATM network due to intra-switch handoff is minimized and the communications path (VCC) is not elongated. Moreover, the MVD of BS_4 is not changed.

In the case of an inter-switch seamless handoff, it

is important to reduce the length of the elongated path formed by the handoff procedure as much as possible. It is also important to avoid extra reassembly procedures for ATM frames. This can be achieved by elongating the communication path from an ATM switch which is common to the communication paths to the old BS and the new BS. To achieve continuity of frame forwarding at the new BS, an additional message, "Coupled Message", is defined to identify the relationship between the elongated path and the corresponding pair of MTs. The coupled message is defined as follows:

- coupled message: For each of the MT associated VCCs of the moving MT, the ATM switching node connecting the old BS establishes a point-point switched virtual connection (SVC) to the new BS for the elongated path via the signalling protocol. The new BS then receives the VPI/VCI value for the elongated path and the MT-associated VCC, and the frames for the MT can then be forwarded again.

Consider an example of inter-switch handoff, with reference to Figure 6. Assume that MT_c, located in BSA C_1, moves to BSA C_2. Since C_1 and C_2 are associated with different switching nodes, X and Y respectively, an inter-switch handoff will be required, as opposed to an intra-switch handoff. The inter-switch handoff scheme requires performance of the following steps:

1. MT_c sends a location message, with the address of BS_2, to BS1. MT_c also sends a connection message with MT(a,c) - 70/100 and MT(b,c) - 70/200 to BS_2.

2. BS_1 then sends a routing message, (70/100, 70/200; ATM BS_1; ATM BS_2), to ATM switching node X.

3. ATM switch X establishes a SVC to BS_2 for each of the MT-associated VCCs (70/100 and 70/200), modifies the corresponding duples in its SRD, and sends a couple message with VCC 70/100 (70/200) to BS_2.

4. BS_2 adds the new MT-pair VCC entry into its MVD and restarts the data transmission procedure.

5. If the ATM switching node X detects that the output port and input port of a mobile connection are identical, i.e. a loop has occurred, it first releases the SVC established for the elongated path and sends a routing message to the adjacent ATM switching node, Z in the case of the present example, in the mobile connection path. The adjacent ATM switching node then establishes a new SVC to the new BS for the elongated path and also goes into a loop detection phase. If there is no loop, the handoff procedure is complete, otherwise this step of the procedure is repeated until all loops have been eliminated, working steadily back through the chain of ATM switching nodes in the mobile communication path, (in the present example this chain is only two switching nodes long).

Once handoff is completed, the elongated path created by inter-switch handoff has been reduced as much as possible by the handoff procedure itself. However, it is quite possible that the elongated path is not the shortest path between the two communicating MTs. A path migration can, if necessary, be applied to migrate the communications path created in the handoff process to a better path. Path migration is thus performed after completion of an inter-switch handoff. In the case of intra-switch handoff there is no need to consider path migrations, i.e. rerouting.

When an inter-switch handoff occurs, the BS for the new BSA first establishes a VCC to the remote BS by executing a routing scheme, e.g. a shortest path scheme. This causes the communication path to migrate to a new, more efficient, path. The flush message protocol of the LAN emulation protocol can be used to maintain the frame order. The establishment and selection of a path between two ATM end stations, suggested in the ATM forum P-NNI, are based on performing a shortest path computation. For the sake of simplicity, the shortest path algorithm can be used with the present invention to find a new path in the migration scheme set out above. This ensures that delays are reduced and bandwidth consumption is minimised by establishment of a virtual connection. If the migration scheme produces a communication path which differs from the communication path established by handoff, then the existing communication path is migrated to the new path, else the original communications path is retained.

A new end-to-end virtual connection must be established for a migrated path. A partner message is used to convey the ATM address of the destined partner BS to the originating BS. A partner message can be defined as follows:

- Partner message: For each of the MT-associated VCCs, the moving MT initiates a location query to obtain the ATM address of the destined partner BS (ATM $BS_{partner}$) and sends a partner message with this ATM address to the BS in the new BSA. The partner message contains all the MT-associated VCCs for the moving MT tagged with the corresponding ATM addresses, each for a partner BS.

CLAIMS

1. A wireless local area network having a plurality of mobile terminals and a plurality of wireless base stations linked by an infrastructure network, characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, and in that both intra-switch and inter-switch mobility is supported by said infrastructure network.

2. A wireless local area network as claimed in claim 1, characterised in that central control means are provided for reconfiguring the wireless local area network by reassigning logical addresses.

3. A wireless local area network as claimed in either claim 1, or 2, characterised in that said wireless local area network is structured into a plurality of logical domains within which traffic can be confined and which exist independently of a mobile terminal's physical location.

4. A wireless local area network as claimed in claim 3, characterised in that said wireless local area network includes overlapping logical domains.

5. A wireless local area network as claimed in any previous claim, characterised in that terminal mobility is achieved by use of a seamless handoff scheme.

6. A wireless local area network as claimed in claim 5, characterised in that an individual data direct VCC is established between each pair of communicating mobile terminals.

7. A wireless local area network as claimed in either

claim 5, or 6, characterised in that there is provided an MVD and an SRD.

8. A wireless local area network as claimed in any of claims 5 to 7, characterised in that a signalling VC is employed for supporting command channel connections.

9. A wireless local area network as claimed in any of claims 5 to 8, characterised in that a handoff VC is employed for transmission of messages relating to terminal mobility.

10. A wireless local area network as claimed in any of claims 5 to 9, characterised in that said seamless handoff scheme employs the following messages:

- a location message;
- a connection message;
- a routing message; and
- a complete message.

11. A wireless local area network as claimed in any of claims 5 to 10, characterised in that when a moving MT initiates a location query in order to obtain an ATM address for a base station in a new cell, the location query is transmitted to an original base station as a location message.

12. A wireless local area network as claimed in any of claims 5 to 11, characterised in that when an MT initiates a connection query in order to obtain MT associated data from the MVD, the connection query is transmitted as a connection message.

13. A wireless local area network as claimed in any of claims 5 to 12, characterised in that a routing message includes data identifying MT-associated VCCs, an originating base station, and a new base station and enables an ATM switch to identify whether a handoff is inter-switch, or intra-switch.

14. A wireless local area network as claimed in any of claims 5 to 13, characterised in that a complete message, containing data on all MT-associated VCCs, is transmitted by an ATM switch, whenever the ATM switch has completed an SRD modification, to a new base station.

15. A wireless local area network as claimed in any previous claim, characterised in that each MT within an area served by an ATM switch has a unique VCI value.

16. A wireless local area network as claimed in any previous claim, characterised in that first means are provided for determining, after completion of an inter-switch handoff, whether, or not, communication is established over an optimum path, and in that second means are provided to migrate said communication to an optimal path, if said path is sub-optimal.

17. A wireless local area network as claimed in claim 16, characterised in that a partner message is employed to transmit an ATM address of a partner BS to an originating BS.

18. A wireless local area network as claimed in claim 16, characterised in that during path migration the flush message protocol of the LAN emulation protocol is employed to maintain frame order.

19. A wireless local area network having a plurality of

mobile terminals and a plurality of wireless base stations linked by an infrastructure network characterised in that said infrastructure network is an ATM switched network having a plurality of ATM switching nodes, in that both intra-switch and inter-switch mobility is supported by said infrastructure network, in that central control means are provided for reconfiguring the wireless local area network by reassigning logical addresses, and in that there is provided an MVD and an SRD, in which an individual data direct VCC is established between each pair of communicating mobile terminals.

20. In a wireless local area network as claimed in claim 19, a method of providing seamless intra-switch handoff, for an ATM switching node, of a MT from a first BS to a second BS, characterised by the following steps:

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;

- the first BS transmits a routing message to the ATM switching node;

- said ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said ATM switching node;

- said ATM switching node sends a complete message identifying all new VPI/VCI pairs to said second base station;

- said second base station adds new MT-pair-VCC associated entries to its MVD; and

- the second base station re-starts data

transmission.

21. In a wireless local area network as claimed in claim 19, a method of providing seamless inter-switch handoff, of a MT from a first BS, connected to a first ATM switching node, to a second BS, connected to a second ATM switching node, characterised by the following steps:

- said MT issues a location message containing ATM addresses for said first and second BSs and a connection message to said second BS;
- the first BS transmits a routing message to the first ATM switching node;
- the first ATM switching node establishes an SVC to the second base station for each of the MT-associated VCCs;
- said first ATM switching node modifies duples corresponding to said MT-associated VCCs in an SRD located at said first ATM switching node;
- said first ATM switching node transmits a coupling message to the second base station;
- the second base station adds the new MT-pair VCC entry into its MVD; and
- the second base station re-starts data transmission.

22. A method as claimed in claim 21, characterised in that, if said second ATM switching node detects that an output port and an input port of a mobile connection are identical, so that a longer looped loop path exists, the

following steps are performed:

- said second ATM switching node releases the SVC established for the longer loop path;
- said second ATM switching node sends a routing message to a third adjacent ATM switching node;
- the third ATM switching node establishes a new SVC to the second base station;
- the third ATM switching node searches for a loop path and, if no loop path is detected completes the handoff procedure;
- if said third ATM switch detects a loop path, the above procedure is repeated with a fourth adjacent ATM switching node.

23. A method as claimed in any of claims 20 to 22, characterised in that, on completion of a handoff procedure for a first MT, in active communication with a second MT, between a first base station and a second base station, said second base station establishes a new VCC to a remote base station, via which the second MT is connected, by executing a routing scheme, and if said VCC differs from the VCC established at handoff, migrates communication to the new VCC.

24. A method as claimed in claim 23, characterised in that said routing scheme is a shortest path scheme.

25. A method as claimed in either claim 23, or 24, characterised in that frame order is preserved by using the flush message protocol of the LAN emulation protocol.

Fig. 1

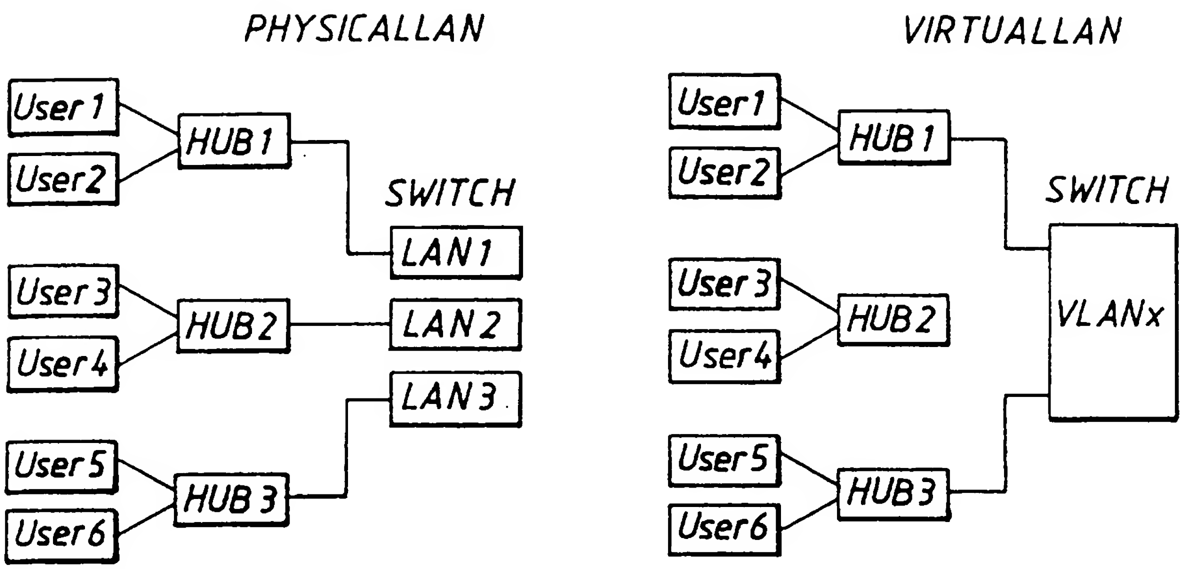

PHYSICALLAN
User 1
User2
HUB 1
SWITCH
LAN 1
User 3
User 4
HUB 2
LAN 2
LAN 3
User 5
User 6
HUB 3
VIRTUALLAN
User 1
User2
HUB 1
SWITCH
User 3
User 4
HUB 2
VLANx
User 5
User 6
HUB 3

Fig. 2

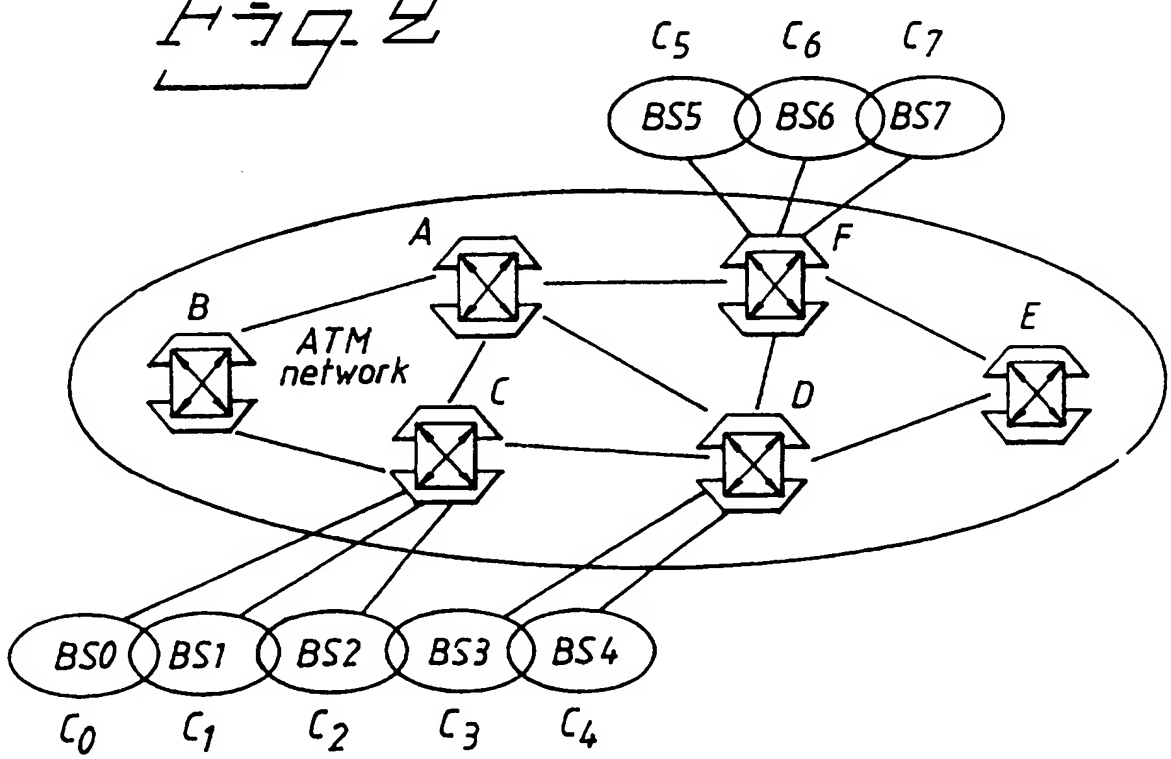

C5
C6
C7
BS5
BS6
BS7
A
F
B
ATM network
E
C
D
BS0
BS1
BS2
BS3
BS4
C0
C1
C2
C3
C4

Fig. 3

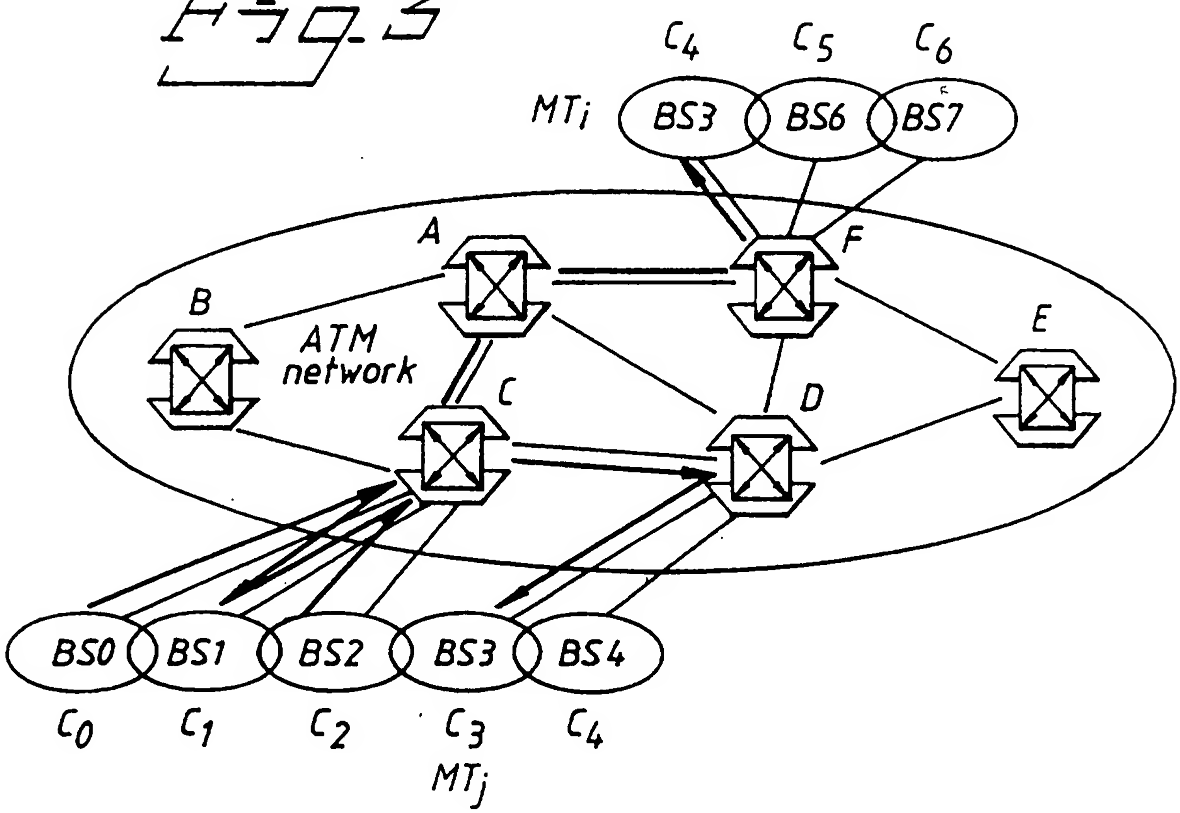
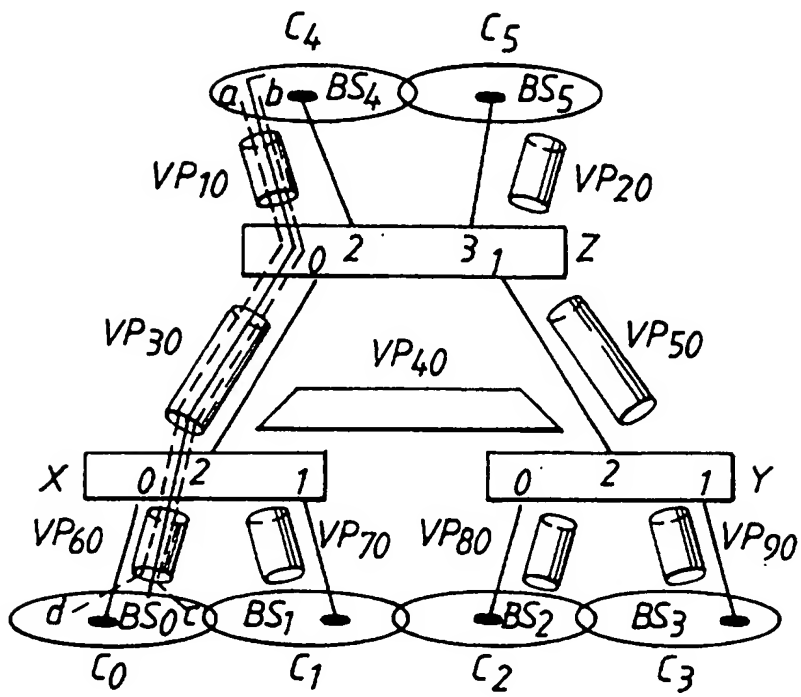

C4
C5
C6
MTi
BS3
BS6
BS7
A
F
B
ATM network
E
C
D
BS0
BS1
BS2
BS3
BS4
C0
C1
C2
C3
C4
MTj

Fig. 4



BS0's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 60/100
MT(b,c) - 60/200
MT(a,d) - 60/300

BS4's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 10/700
MT(b,c) - 10/800
MT(a,d) - 10/900

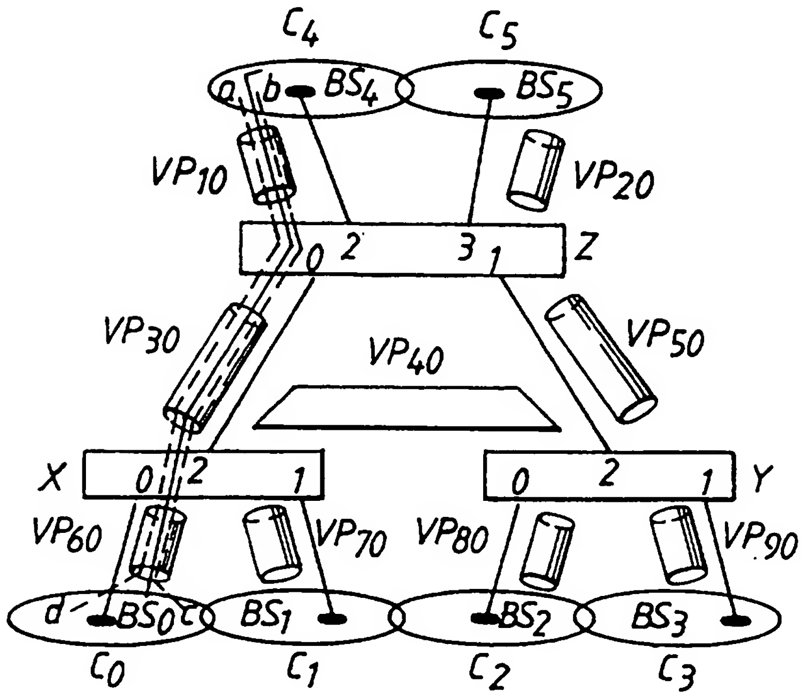
Switch X's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
60/100	0	30/400	2
30/400	2	60/100	0
60/200	0	30/500	2
30/500	2	60/200	0
60/300	0	30/600	2
30/600	2	60/300	0

Switch Z's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
30/400	0	30/400	2
10/700	2	60/100	0
30/500	0	30/500	2
10/800	2	60/200	0
30/600	0	30/600	2
10/900	2	60/300	0

Fig-5



BS_1's MT Pair-VCC Mapping Database (MVD)

MT(a,c)-70/100
MT(b,c)-70/200

BS_4's MT Pair-VCC Mapping Database (MVD)

MT(a,c)- 10/700
MT(b,c)- 10/800
MT(a,d)-10/900

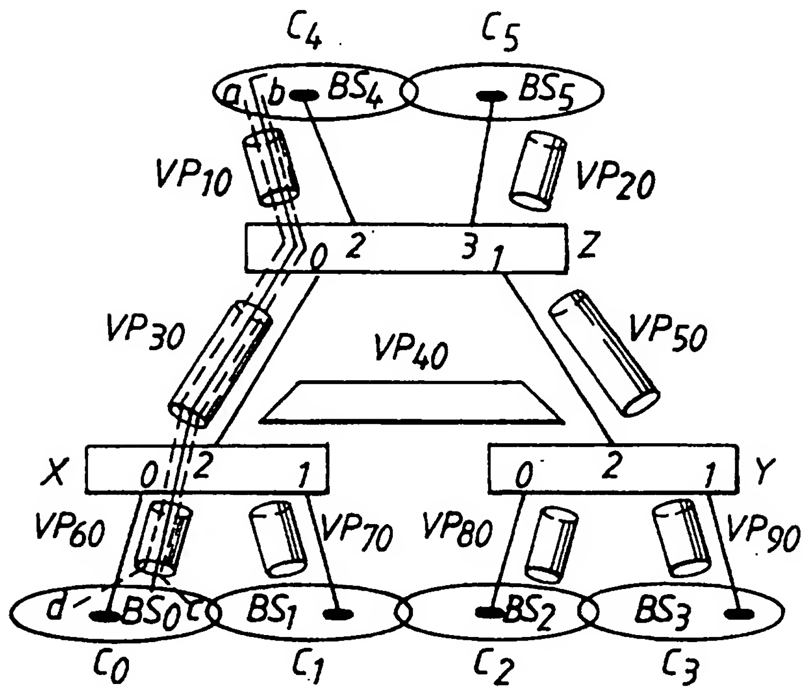
Switch X's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
60/100>70/100	0>1	30/400	2
30/400	2	60/100>70/100	0->1
60/200	0	30/500	2
30/500	2	60/200>70/200	0->1
60/300	0	30/600	2
30/600	2	60/300	0

Switch Z's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
30/400	0	10/700	2
10/700	2	30/400	0
30/500	0	10/800	2
10/800	2	30/500	0
30/600	0	10/900	2
10/900	2	30/600	0

Fig. 6



BS_2's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 80/350
MT(b,c) - 80/450

BS_4's MT Pair-VCC Mapping Database (MVD)

MT(a,c) - 10/700
MT(b,c) - 10/800
MT(a,d) - 10/900

Switch Y's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
80/350	0	50/150	2
50/150	2	80/350	0
80/450	0	50/250	2
50/250	2	80/450	0

Switch Z's Routing Database (SRD)

IN-VCC	IN-PORT	OUT-VCC	OUT-PORT
30/400>50/150	0->	10/700	2
10/700	2	30/400>50/150	0->1
30/500>50/250	0	10/800	2
10/800	2	30/500>50/250	0->1
30/600	0	10/900	2
10/900	2	30/600	0

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00108

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5487065 A (ANTHONY S. ACAMPORA ET AL), 23 January 1996 (23.01.96), column 2, line 63 - column 5, line 13; column 6, line 4 - column 7, line 60, figures 1,2	1,5-12,15-18
Y		2-4,19-21
A		13,14,22-25
	--	
Y	BUSINESS COMMUNICATIONS REVIEW, Volume 23, December 1993, David H. Axner, "Differing Approaches to Virtual LANs", page 42 - page 45, see especially page 42	2-4,19-21
A		13,14,22-25
	--	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 1997	29 -05- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Kenneth Ahrengart Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

20/05/97

International application No.
PCT/SE 97/00108

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5487065 A	23/01/96	EP 0700604 A	13/03/96
		JP 8510884 T	12/11/96
		WO 9428645 A	08/12/94
		US 5528583 A	18/06/96
		US 5590125 A	31/12/96